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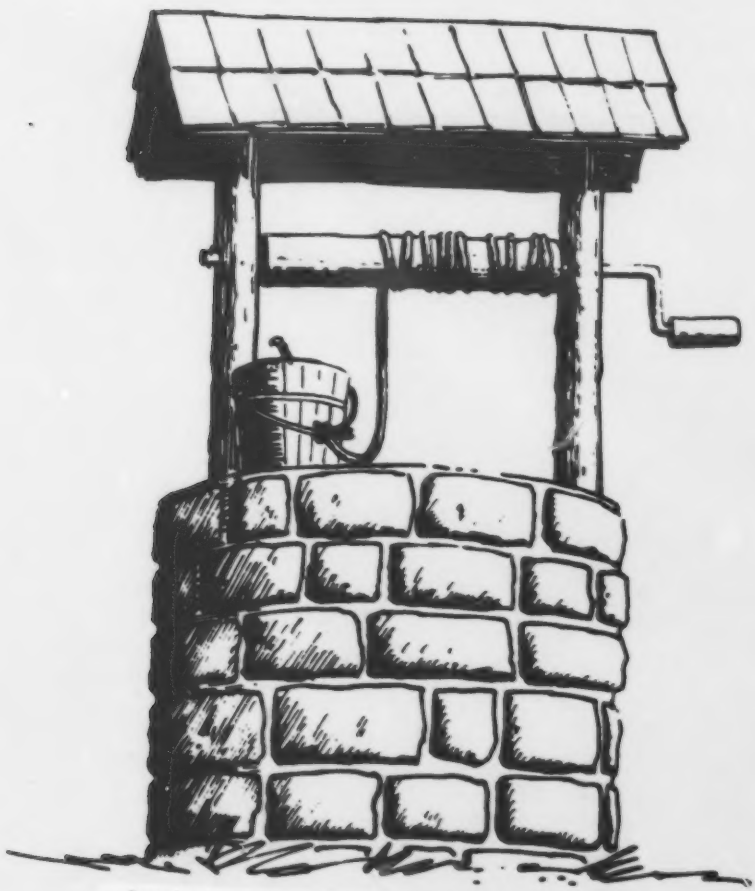
EVALUATION OF SALT WATER DISPOSAL INTO POTENTIAL GROUND-WATER RESOURCES



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The quality of the water in the Glorieta Formation in western Oklahoma was tested by sampling an oil test well. The test was made to obtain data which would be used in evaluating the potential of the formation as a water source or for brine disposal. The water in the formation is high in dissolved solids and would have to be either desalted or mixed with a high proportion of good-quality water before the water could be used for such purposes as irrigation or municipal supply. The Glorieta Formation is composed of very fine unconsolidated sand. Completion and pumping of water wells in the formation would be difficult and considerably more expensive than present water wells in the High Plains area. (Knapp—USGS)

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EVALUATION OF SALT WATER DISPOSAL INTO POTENTIAL GROUND-WATER RESOURCES

by

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for the

OFFICE OF RESEARCH AND MONITORING

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Abstract

The Glorieta Sandstone was developed and tested for water quality in an abandoned oil test located in western Texas County, Oklahoma to evaluate the use of the formation as a potential water source.

Results of chemical analyses (e.g., chloride content is 9,400 mg/l) support previous conclusions that water from the Glorieta is high in chloride and dissolved solids and cannot be used for most beneficial purposes without being desalinized or being mixed with a high proportion of water of low dissolved solids content.

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CONCLUSIONS

1. The use of an abandoned oil test proved satisfactory in determining the quality of the water in the Glorieta Formation penetrated by this well. The test was made to obtain data which would be used in evaluating the potential of the formation as a water source.

2. The chemical analysis of water from the Glorieta Sandstone indicates that the water in the formation is high in dissolved solids and would have to be either desalted or mixed with a high proportion of good-quality water before the water could be used for such purposes as irrigation or municipal supply.

3. The Glorieta Formation is composed of very fine unconsolidated sand. Completion and pumping of water wells in the formation would be difficult and considerably more expensive than present water wells in the High Plains area.

INTRODUCTION

This project was conducted as a continuation of other work entitled "Determination of Pollutional Potential of the Ogallala Aquifer by Salt Water Injection".[1] Both projects are concerned with the injection of oil field brines into the Glorieta Formation which lies a few hundred feet below the Ogallala Formation, a major fresh water aquifer in several states. Both projects were conducted in Texas County in the Panhandle of Oklahoma.

The first project dealt primarily with the pollutional potential by establishing the relationship of the hydraulic potentials of each geologic formation. In the report of that project, it was stated that the quality of native water in the Glorieta was not adequately established and an evaluation of that formation as a potential water resource could not be made.

This report, therefore, presents findings and recommendations relative to water quality information in the Glorieta in an area where there has been no previous brine disposal.

The project was designed to provide water quality information at the lowest possible cost. It entailed perforating and testing the Glorieta Section in an existing but abandoned oil-test well in the western part of Texas County, Oklahoma. The well was ideally suited for this purpose in that it was drilled and plugged recently by a major oil company and has casing extending through the Glorieta Formation.

The Glorieta Sand is extremely fine-grained sand, rounded and completely unconsolidated (like beach sand). Electrical logs indicate that very thin lenticular shale lenses exist throughout the Glorieta Section.

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FIELD PROCEDURE

The well used in this project was the Texaco No. 1 H.C. Hitch, Jr. As shown in Figure 1, it is located in the NE 1/4 of Section 5, Township 2 North, Range 10 ECM. It was completed in May of 1968 to a depth of 5509 feet and found to be a dry hole. The well was subsequently plugged in September, 1969. The well is cased with 1596 feet of 8 5/8" casing which extends from the land surface through and below the Glorieta Formation. The casing at the beginning of this test was plugged with cement and heavy mud.

The field phase of this project was performed during the eight-day period, September 27 to October 4, 1971. The principal steps of this phase are listed and discussed as follows:

1. The cement plugs and mud in the casing were removed by rotary drilling and bailing.

2. A new plug consisting of 35 sacks of cement was set in the casing from 1475 feet to 1589 feet below land surface.

3. The hole was swabbed and bailed dry.

4. Observations were made for two hours to see whether or not there would be leakage past the new cement plug. No fluid entered the hole during this observation period.

5. A Gamma Ray-Collar Log was run from 1450 feet to surface. This log provided the basis for determining the position and thickness of the Glorieta Formation and the interval to be perforated. The log showed that the top of the Glorieta is 993 feet below land surface and the base of the formation is at 1176 feet.

6. The well was jet perforated with four shots at 1003 feet, which is ten feet below the formation top. The perforations were made while the hole was still dry.

7. After the casing was perforated, fluid entered the well and rose to 790 feet. The well was left in this condition for about sixteen hours before the process of removing water from the well was begun.

8. To assure that the water samples collected for chemical analysis were not contaminated with drilling fluids, a large amount of water was removed from the well. This water removal was achieved by bailing. While bailing, 36 trips were made, representing approximately 23 barrels of water. During the bailing operations, water quality parameters were monitored until the quality stabilized thereby assuring that Glorieta water was indeed being sampled.

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9. A large amount of sand entered the well during the bailing operations. This condition resulted largely because the sand composing the formation was fine grained and unconsolidated. The condition necessitated that all samples had to be filtered thoroughly to remove the suspended fine sand and silt before chemical analysis could be performed. Measurements revealed that 185 feet of sand settled out on top of the plug in the well; this represents about 65 cubic feet of sand.

10. After completion of the tests, the well was plugged in compliance with the Rules and Regulations of the Oklahoma Corporation Commission.

11. All equipment, debris, and drilling mud were removed from the project site; the casing was cut off three feet below ground level and was capped with a steel plate; then the location and access road were leveled.

Figure 1 VICINITY MAP

ANALYTICAL PROCEDURES

Throughout the swabbing and bailing operations, water samples from the well were periodically analyzed in the field for pH, specific conductance, chlorides, and total alkalinity. These samples, which were quite turbid, were filtered through a Millipore glass-fiber prefilter before analysis. Specific conductance and pH were determined respectively by means of an Industrial Instruments Model RB-3 conductivity meter and an Orion Model 901 Research Ionalyzer. Chlorides were determined by titration of samples with mercuric nitrate.(2) Total alkalinity was determined by the mixed bromcresol green-methyl red indicator method.(3)

When chlorides and total alkalinity of water from the test well had remained essentially constant for approximately three hours, indicating that water truly representative of that in the Glorieta Aquifer was being obtained, samples were collected for shipment to the laboratory to be analyzed for sulfate, total hardness, total dissolved solids, nitrate, nitrite, total kjeldahl nitrogen, phosphorus, and selected metals. These samples were initially collected in stainless steel buckets and then were further processed after allowing a short period for settling of suspended matter.

Samples to be analyzed for sulfate, total hardness, and total dissolved solids were decanted from the stainless steel buckets directly into suitable containers for shipment to the laboratory, with no further treatment in the field. Before analysis in the laboratory, these samples were filtered through Whatman No. 566 filter paper. Sulfate was determined by the standard turbidimetric method, employing Sulfaver (Hach Chemical Company) as conditioning reagent.(4) The complexometric titration method was employed for total hardness determination with cyclohexanediaminetetraacetic acid being utilized as the titrant.(5) Total dissolved solids were determined by evaporating 100 ml aliquots of the filtered samples to dryness on a steam bath, and weighing after further oven drying at 103°C.(6)

For determination of nitrates, nitrites, total Kjeldahl nitrogen, and total phosphorus, samples were decanted from the stainless steel collection buckets into shipping containers and then were "fixed" by addition of 2 ml H_2SO_4/liter in the field, before return to the laboratory. Nitrates and nitrites were determined by the automated hydrazine reduction method,(7) with the method of standard additions being employed to compensate for interferences produced by other components of the samples. Total Kjeldahl nitrogen was determined by a standardized procedure for water analysis, employing titration as the final analytical step.(8) For determination of total phosphorus, all phosphorus was first converted to orthophosphate by digestion of samples with sulfuric acid-ammonium persulfate.(9) In order to eliminate potential interferences and increase sensitivity of the analyses, the orthophosphate was then determined by a procedure utilizing organic solvent extraction. This procedure was essentially that of Jenkins,(10)

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with the following exceptions: (1) benzene-isobutyl alcohol (1:1) was used as extracting solvent; (2) 15 drops of dilute solution of stannuous chloride in glycerol[11] were employed as reducing agent; (3) 12 - 15 minutes were allowed for color development before determination of absorbance.

Samples to be analyzed for metals were filtered through 0.45μ Millipore filters and "fixed" by adding 2 ml concentrated nitric acid per liter of filtered sample in the field. Sodium, potassium, calcium, magnesium, aluminum, strontium, and barium were determined by atomic absorption spectrophotometry, utilizing a Perkin-Elmer Model 403 atomic absorption spectrophotometer and standardized analytical procedures.[12, 13] To obviate potential interferences in analysis of barium and strontium, standard addition was employed for determination of these metals.

Zinc, cadmium, iron, tin, manganese, copper, nickel, lead, and hexavalent chromium were determined by emission spectroscopy, employing a Jarrell-Ash Mark IV Ebert convertible plane grating spectrograph with rotating disc attachment for sampling and a high voltage spark for excitation. The metals were concentrated for analysis by chelating with ammonium pyrrolidine dithiocarbamate and extracting the metal chelates from the water samples with chloroform.[14]

Boron was determined by the Curcumin method.[15]

RESULTS

The results of this project are expressed as water quality information for native water in the Glorieta Formation at the test site. This information is shown in Table 1, along with the United States Public Health Service Drinking Water Standards for comparative purposes. It can be seen by examining Table 1 that 50 percent of the applicable standards are exceeded by a considerable margin.

This chemical analysis of Glorieta water is in line with data which the U.S. Geological Survey collected for six different locations in Texas County. These six analyses show the Glorieta water to range in chloride concentration from 10,196 to 31,028 parts per million. On the basis of these analyses and several others collected in other parts of Oklahoma, Kansas, and Texas, the U.S. Geological Survey concluded that "the water is high in chloride and dissolved solids".(17)

Table 1

Chemical Analysis of Water
From the Glorieta Sandstone*

Parameter	Glorieta Water	USPHS Drinking Water Standards (16)
Temperature	21.0°C	
Specific Conductance	34,000 µmhos/cm	
pH	7.5	
Cl	9,400 mg/l	250 mg/l
Total Alkalinity as $CaCO_3$	1,740 mg/l	
Total Dissolved Solids	22,649 mg/l	500 mg/l
Total Hardness	2,400 mg/l	
SO_4	3,475 mg/l	250 mg/l
NO_3-N	0.5 mg/l	45.0 mg/l
NO_2-N	<0.1 mg/l	
Total Kjeldahl N	2.7 mg/l	
P	0.1 mg/l	
Na	7,700 mg/l	
Ca	112 mg/l	
Mg	163 mg/l	
Sr	12 mg/l	
Ba	<10 mg/l	1.0 mg/l
Al	<1 mg/l	
Zn	0.34 mg/l	5.0 mg/l
Cd	<0.05 mg/l	0.01 mg/l
Fe	1.6 mg/l	0.3 mg/l
Sn	<0.1 mg/l	
Mn	0.11 mg/l	.05 mg/l
Cu	0.05 mg/l	1.0 mg/l
Ni	0.14 mg/l	
Pb	0.10 mg/l	0.05 mg/l
Cr	<0.05 mg/l	0.05 mg/l
B	0.1 mg/l	

*Sample collected October 1, 1971, from Texaco Oil Test, Hitch No. 1, located NE 1/4, NE 1/4, Sec. 5, T2N, R10ECM, Texas County, Oklahoma.

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A project of this nature necessarily involves the energy, talent, and cooperation of a number of people to whom proper credit should be given.

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Special acknowledgement is also made of Texaco, Inc., who made the project possible by allowing their oil test to be utilized for this purpose.

Henry C. Hitch, Jr., is acknowledged for his cooperation in granting access to the project site.

Our special thanks to George Freeman, Jr., and Virgil Higgins of the Texas County Irrigation Association for their assistance in obtaining temporary road (provided by county) and their encouragement and advice during testing.

Leslie G. McMillion, who served as Project Officer from the Environmental Protection Agency, is acknowledged with thanks for his assistance in all phases of this project. Recognition of others in the Environmental Protection Agency who participated are: Messrs. W. J. Dunlap, Roger Cosby, James McNabb, and Jack Keeley, members of the National Ground Water Research Program of the Robert S. Kerr Water Research Center. Their assistance was invaluable in both the field and laboratory phases of analytical determinations.

DeWayne Reeves, Supervisor for the prime contractor, for all his suggestions and assistance in securing conclusive tests is also acknowledged.

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